Review of Palaeobotany and Palynology 195 (2013) 26–36

Contents lists available at SciVerse ScienceDirect

Review of Palaeobotany and Palynology

journal homepage: www.elsevier.com/locate/revpalbo

Pollen percentage thresholds of *Abies alba* based on 13-year annual records of pollen deposition in modified Tauber traps: perspectives of application to fossil situations

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ARTICLE INFO

Article history:
Received 3 October 2012
Received in revised form 13 March 2013
Accepted 18 March 2013
Available online 8 April 2013

Keywords:
Abies alba
pollen accumulation rate
modified Tauber trap
pollen threshold value
Central-Eastern Europe

ABSTRACT

Abies alba (fir), a submontane tree from Central European mountains and uplands, is of special interest for palaeoecological and palaeoclimate interpretations due to its sensitivity to air and soil humidity. Its present distribution limit in the uplands of SE Poland is still a matter of debate. In the Holocene fir expanded to Poland very late, but early fir populations are supposed to occur in the Šumava Mts (Czech Republic). The study aims: to estimate pollen thresholds for fir presence/absence in Bohemia (Czech Republic) and Poland on the basis of modified Tauber pollen traps; to use these thresholds for tracing fir presence in two pollen diagrams from Poland (Słone and Bezedna lakes) in the border zone between the Roztocze region (with fir forest stands today) and Polesie (where fir has never played an important role); and to investigate how the percentage presence/absence threshold can be used to trace the occurrence and abundance of fir trees in the Šumava Mts based on the pollen diagrams of Rokytecká slat' and Mrtvý luh.

The fir pollen thresholds estimated in terms of PAR (pollen accumulation rates or pollen influx) range from 843 (grains cm^{-2} $year^{-1}$) (Roztocze) to 61 (Krkonoše) and 49 (Šumava). Percentage thresholds range from 0.3% in Krkonoše where fir trees are not present within 4 km to 22% in fir-dominated woodland of the Roztocze, providing evidence of strong underrepresentation of fir in the pollen deposition. Application of these percentage thresholds to the Słone and Bezedna pollen diagrams indicates that occurrence of fir in the region is possible from 3.5 cal ky BP onwards, though the evidence is not decisive. In the Šumava, a low representation of fir pollen (1–2%) reflecting presence of scattered fir trees was detected as early as ca. 7.0 cal ky BP.

1. Introduction

Abies alba (fir) is an important European forest-forming tree of great interest for palaeoclimate and palaeoecological reconstructions because it is both sensitive to climate change and to human impact (Rybníček and Rybníčková, 1978; Tomanek, 1994; Zagwijn, 1996; Tzedakis et al., 2002; Finsinger and Tinner, 2006; Tinner and Lotter, 2006; Šamonil and Vrška, 2007; Rybníček and Rybníčková, 2009; Kozaková et al., 2011; Tanţău et al., 2011). North of the European Alps, fir prefers an oceanic cool and wet climate. Limiting factors for its optimum development are mean July temperature of 15 °C and mean January temperature of −4.5 °C (Jaworski and Zarzycki, 1983). Northern limit of fir range is associated with annual precipitation of 600 mm, but optimum conditions in the Carpathians are associated with 700 mm of annual totals (Obidowicz et al., 2004). Its ecological requirements are between those of spruce (*Picea abies*) and beech (*Fagus sylvatica*). Fir tolerates low temperatures well in the areas with considerable air humidity. Drought during the growing season may result in the death of *A. alba* trees (Jaworski and Zarzycki, 1983; Tomanek, 1994; Obidowicz et al., 2004).

At present, fir in Central Europe (Fig. 1A) is mainly distributed in the submontane zone, at altitudes above 400–800 m, and only in the Carpathian foreland of southern Poland does its distribution range extend down into the colline belt (Fig. 2A). In its northern distribution range in Poland, in the Holy Cross Mts (=Góry Świętokrzyskie) and in the Roztocze region of south-eastern Poland (Zając and Zając, 2001), fir tree stands are widespread. Together with beech, fir forms also forest stands in the mountains at elevations of 500–1100 m a.s.l., frequently admixed with spruce. In the Tatra Mountains (part of the Carpathian Mts in southern Poland) it occurs very locally up to very high elevations of 1450 m a.s.l. (Tomanek, 1994). North of the Middle Polish Uplands only few and small stands of fir have been recorded. It is, however, still a matter of debate whether the limit of continuous fir distribution

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http://dx.doi.org/10.1016/j.revpalbo.2013.03.006

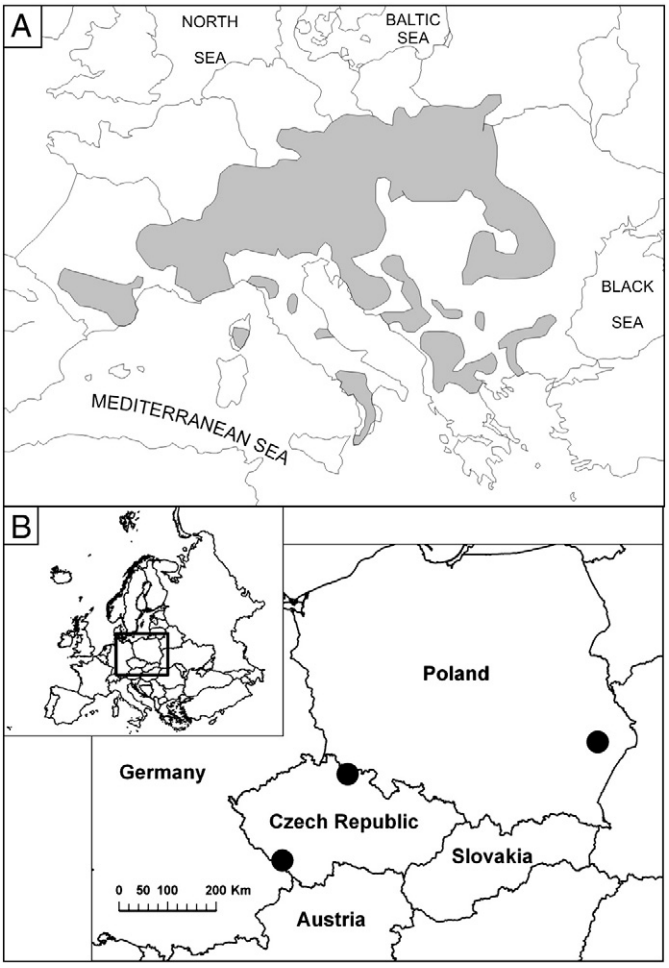

Fig. 1. A — Present-day distribution of *Abies alba* in Central Europe (after Jalas and Suominen, 1973 and Boratyński, 1983); B — Regions of pollen monitoring in Poland (Roztocze region) and the Czech Republic (Šumava Mts and Krkonoše Mts) in Europe.

was previously more to the north, since suitable habitats seem to exist in the Lublin Upland (Matuszkiewicz, 1991). For example, a suitable location might be the Chełm Hills at the northern edge of the Lublin Upland where Zając and Zając (2001) reported isolated fir stands, 50–70 km north of the present continuous fir limit in the Roztocze region. The landscape is hilly with Cretaceous rocks and has abundant beech in forests on dry ground, in which one would also expect fir. However, no pollen-bearing deposits have been found up to now to test the possible former presence of fir.

In the Czech Republic, fir is at present mostly distributed in the lower montane zone. In the Šumava Mts. fir ascends to 1300 m a.s.l. (Hejný and Slavík, 1997) and in the Krkonoše Mts up to 1000 m a.s.l. (Musil and Hamerník, 2007). The proportion of fir in the Šumava forests is small (only 0.7%). The highest representation (1.1%) is observed between 950 and 1150 m a.s.l. Below 950 m a.s.l., where the best conditions for fir may be expected, it occupies merely 0.3% according to the Forest inventory 1999–2002 (Zatloukal et al., 2005).

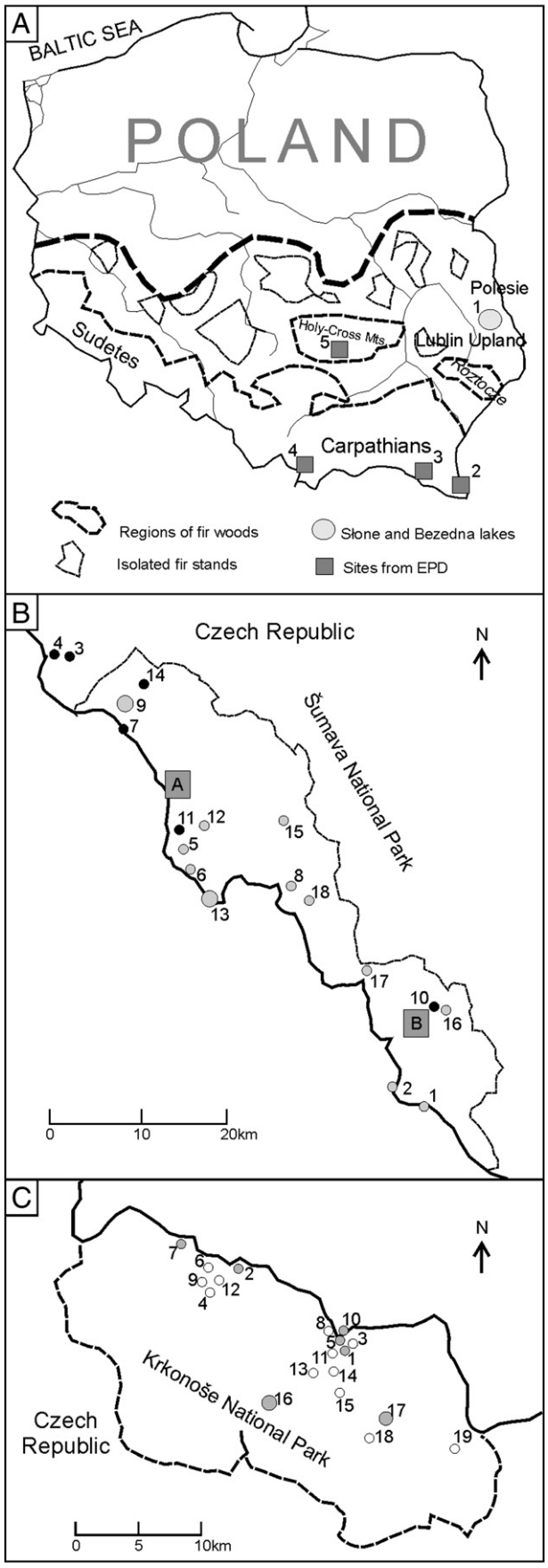

Fig. 2. Location of the sites under investigation: A — in Poland. Explanations: distribution of *Abies alba* in Poland (after Zając and Zając, 2001). Marked are the Roztocze region (pollen trapping sites), two fossil sites (1 — Słone and Bezedna lakes in the northern part of the Lublin Upland) and four fossil sites from the EPD (2 — Tarnawa Wyżna, 3 — Tarnowiec, 4 — Puścizna Rękowiańska and 5 — Słopiec). B — in the Šumava National Park. Explanations: fossil pollen sites Rokytecka slat' (A) and Mrtvy luh (B); distance to *Abies* trees between 0.2 and 0.9 km (black circles), more than 1 km (grey circles), *Abies* trees locally abundant — up to 20–30% (big circles). C — in the Krkonoše National Park. Explanations: distance to *Abies* trees less than 1 km (big circles), less than 2 km (grey circles), between 2 and 3.5 km (white circles).